

ELEMENTAL INVESTIGATION OF TALCUM BABY POWDER BY X-RAY FLORESCENCE AND FAST NEUTRON ACTIVATION TECHNIQUES

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Abstract

Different samples of Egyptian and Hungarian talcum powders were studied, using X-ray fluorescence (XRF) and Fast Neutron Activation Analysis (FNAA) techniques to ensure the safety of its use. The K (X-rays) and the gamma-rays were measured, using Si(Li) and high-purity germanium (HPGe) spectrometers to detect and determine qualitatively and quantitatively the constituents of the studied samples. The concentrations of the elements (Mg, Si, Al, Fe, Zn, and Ba) were measured and their presence was confirmed by γ -ray, lifetime and/or XRF measurements. One of these samples was also studied, using the Environmental Scanning Electron Microscope (ESEM).

Key Words: *X-Ray Florescence; Fast Neutron Activation Analysis; Talcum Powder*

1. INTRODUCTION

Many years ago, our skins were thought of as an impenetrable barrier, but now we know about it differently. Substances that come into contact with the skin are absorbed and eventually find their way into the blood stream. Toxins and other harmful products accumulate in the vital organs over a period of time causing many problems with our bodies. Talc is a native hydrous magnesium silicate sometimes containing a small portion of aluminum silicate [1]; it can be used as a dry lubricant. It is similar in its chemical composition as asbestos, a well known cancer-causing agent. Talc is found in many baby powders, feminine powders and cosmetics. Talc's harmful effect on human tissues has been known for quite some time [2-7].

It was thought that for the safety of using talcum powder, it is essential to study the elemental constituents of the baby powders as it is excessively in contact with the babies' skin and could be accidentally inhaled by them. This study was achieved using the XRF, FNAA and the ESEM techniques.

2. SAMPLING AND EXPERIMENTAL PROCEDURE

Different samples of Egyptian (E) and Hungarian (H) talc powders were studied using the XRF, FNAA, and ESEM techniques. The powders were dried and disks of 19 mm in diameter and about 2-3 mm thick were pressed, weighed and then used. For the fast neutron activation,

a 200 keV accelerator at the Institute of Experimental Physics of Kossuth University was used as a neutron generator in the D-T mode (14 MeV).

2.1. X-Ray Florescence Measurements

The K X-rays were detected using a Si(Li) spectrometer; the Si(Li) detector has an area of about 200 mm² and a resolution of 200 eV at the 5.9 keV of (⁵⁵Fe). This detector was coupled to an ATOMKI main amplifier and a computer ADC card. The system calibration was determined experimentally, using ⁵⁴Mn, ⁵⁷Co, and ²⁴¹Am standard γ -sources. For qualitative measurement the prepared samples of 19 mm diameters were excited by ²⁴¹Am and ¹²⁵I ring-shaped sources.

2.2. Fast Neutron Activation Analysis (FNAA) Measurements

Single gamma-ray measurements were achieved, using a high resolution ORTEC hyper-pure germanium (HPGe) detector of volume 100 cc and efficiency of 30 %. A cylindrical lead-shield of five cm thickness, which contains inner concentric thin cylinders of Cd, Cu, Fe, and Al with a thickness of 2 mm for each, was used to shield the detector and to reduce the effect of background.

Standard gamma sources, of ²²Na, ⁵⁷Co, ⁶⁰Co, ¹³³Ba, ¹³⁷Cs and ¹⁵²Eu, were used for both energy and efficiency calibrations of the system.

The samples were located on the tritium (T) target, of the neutron generator, and were irradiated with fast neutron for a period of one hour. The cooling time for each sample was one minute. High purity aluminum foils were used for flux monitoring and the measured flux for each irradiation for samples E1, E2, H1, H2, and H3 was (2.67×10^8 , 3.87×10^8 , 3.63×10^8 , 5.56×10^8 , and 4.34×10^8 n.cm⁻²sec⁻¹) respectively. Each sample was measured several times and the gamma ray spectra were analyzed, using different tables⁽⁸⁻¹⁰⁾ and computer programs. The concentration was estimated, using the different gamma transitions of each element and the average value is given. The nuclear parameters used in the present investigation were accepted from references [8-10].

2.3. Environmental Scanning Electron Microscope (ESEM) Analysis

Highly purified picked mineral grains representing the E2 sample were investigated, using NMA Phillips Environmental Scanning Electron Microscope (ESEM model XL30). The ESEM-EDAX analysis was made to investigate morphological characteristics of this sample as well as semi-quantifying their elemental composition. Mineral grains were examined without coating at low vacuum mode (0.9 torr, at 30 KV) with back detector. The ESEM – EDAX analysis was made for the sample grains using a counting time of 180 sec for some selected spots near the center of the grain to avoid diffraction of the electron beam at the grain margins.

3. EXPERIMENTAL RESULTS AND DISCUSSION

The present FNAA measurements, life time, ESEM and/or X-ray detections confirmed the existence of Ba, Zn, Al, Fe, Mg and Si elements in the studied Egyptian and Hungarian samples. The concentration values, represented in Table 1, for these confirmed elements were determined utilizing fast neutron activation tool followed by successive gamma-ray measurements.

Barium was confirmed to be, in some of the studied samples, due to the observation of a 662 keV gamma transition which belongs to ^{137m}Ba , due to the $^{138}\text{Ba}(n,2n)^{137m}\text{Ba}$ reaction. Barium is most commonly inhaled as fine dust or absorbed through cuts or lesions on the hands of people who handle compounds containing the material. At low doses, barium acts as a muscle stimulant and at higher

Table 1. Concentrations (in ppm) of different elements in the studied samples

Elements	Sample E1	Sample E2	Sample H1	Sample H2	Sample H3
Ba		1290 ± 0021			2095 ± 00097
Zn	475 ± 0043	331 ± 0131		7098 ± 0040	2604 ± 00242
Al	11075 ± 0044	10908 ± 0056	13184 ± 0069	7800 ± 0052	11595 ± 00493
Fe	4623 ± 0338	3877 ± 0261	5943 ± 0207	2332 ± 0010	1253 ± 00046
Mg	188324 ± 4186	156335 ± 2132	279108 ± 2484	123973 ± 4863	249797 ± 06763
Si	219546 ± 6625	194493 ± 8915	325454 ± 7179	145029 ± 6606	328508 ± 35438

doses affect the nervous system eventually leading to paralysis. Acute and sub-chronic oral doses of barium cause vomiting and diarrhea, followed by decreased heart rate and elevated blood pressure. Higher doses result in cardiac irregularities, weakness, tremors, anxiety, and dyspnea [11].

Zinc was found to be present also in different samples due to the observation of a 670 keV gamma transition which belongs to ^{63}Zn due to the $^{64}\text{Zn}(n,2n)^{63}\text{Zn}$ reaction. Zinc is considered to be relatively nontoxic, particularly if taken orally. However, manifestations of over-toxicity symptoms (nausea, vomiting, epigastric pain, lethargy, and fatigue) will occur with extremely high zinc intakes [12].

From the qualitative analysis, it was thought that the samples contained cerium due to the observation of a gamma transition which was thought to belong to ^{139m}Ce . Yet, after a careful study and repeating different runs for each sample to measure the life-time of the different gamma transitions, it was confirmed to be the double escape peak of the 1779 keV transition which belongs to ^{28}Al . In addition, the following gamma transitions 1273, 2029, and 2426 keV were confirmed to belong to ^{29}Al , each gamma transition was used to calculate the concentration of silicon in each of the studied samples, but the value obtained using the 1273 keV transition was greater than that using the 2029 and 2426 keV transitions. This was due to the single escape peak of 1779 keV superimposed on it. Therefore, a correction was made by adding the concentration of the double escape peak at 757 keV together with that due to the single escape peak to the concentration due to the photo peak at 1779 keV. This gave a value in agreement with that obtained using the transitions of ^{29}Al at 2029 and 2426 keV to indicate the concentrations of Si in the different samples, and the average value is given.

It is estimated that since 1962, between one and two million women have had **silicon** breast implants to enhance their physical appearance. Some 30 years later, thousands of women are second guessing the wisdom of this choice because they are now suffering with a new illness, silicon toxicity and immune dysfunction syndrome [13]. Yet, Silicon is often used in herbal remedies to promote strength in the hair, skin, and nails.

A gamma transition was observed at about 845 keV, which may be due to **aluminum** and/or **iron**, but a 1014 keV transition was observed and proves the presence of Al in the samples. Also, an 1811 keV transition was observed and the presence of Fe is also confirmed. Symptoms of fatigue are often thought to be from too little iron in the body. But, fatigue may also indicate too much iron in the body. Iron is brought into the body from the small intestine. In the blood stream, the iron is transported to be used for making our red cells and to perform other functions in the body [14]. The body stores most of the excess iron in the liver. When the liver is full then the liver starts making storage chemical containers for the iron. It causes hemochromatosis, the disease of iron overload [15].

Humans are exposed to aluminum from a variety of environmental sources. Although an increase in body stores of Aluminum as a result of transfer through the skin is probably negligible, exposure is common from the use of deodorants, toothpaste, dental amalgams, baby powder, cosmetics and others containing Aluminum. Aluminum inhaled from dust is retained in pulmonary tissue and prebronchial lymph nodes but is largely excluded from other tissues. The aluminum concentration in pulmonary tissues does not correlate with that in other tissues. Aluminum levels in tissue are generally low in adults with normal renal function. Bone and liver tissues are most frequently affected by increased absorption and/or decreased clearance of aluminum. Physical symptoms of aluminum toxicity may be brittle bones or osteoporosis; also kidney malfunction may also result. Hyperactivity, memory disturbances, and learning disabilities may result from even mildly elevated levels of aluminum. Aluminum is also found in some seniors with extreme memory loss, absent-mindedness, or dementia. Science has been linking elevation of aluminum in the body with Alzheimer's disease for years [16].

The 1369 and 2754 keV gamma ray transitions obtained in the different spectra, belong to ^{24}Na which may be produced by $^{27}\text{Al}(n,\alpha)^{24}\text{Na}$ and/or $^{24}\text{Mg}(n,p)^{24}\text{Na}$ reaction; also the single and double escape peaks of 2754 keV were observed. The $^{27}\text{Al}(n,\alpha)^{24}\text{Na}$ reaction was excluded since the concentrations calculated for this reaction was incredibly high and not in agreement with that obtained due to the $^{27}\text{Al}(n,p)^{27}\text{Mg}$ reaction and, therefore, the presence of ^{24}Na was accepted to indicate the presence of magnesium in the samples. **Magnesium** is an essential mineral and is closely related to calcium and phosphorus in body function. The average adult's body contains approximately one ounce of magnesium. It is the fifth mineral in abundance within the body behind calcium, phosphorus, potassium and sodium. Although, about 70 percent of the body's magnesium is contained in teeth and bones; its most important functions are carried out by the remainder which is present in the cells of the soft tissues and in the fluid surrounding those cells.

Calcium and magnesium levels need to be maintained in balance since they have an antagonistic relationship. An excess of one implies a need for the other to maintain balance. High levels of magnesium can develop in patients with kidney failure and in elderly people whose kidney functions are reduced. This is especially true with magnesium supplementation [17].

3.1. Environmental Scanning Electron Microscope (ESEM) Analysis

The Environmental Scanning Electron Microscope was used to study sample E2. Twenty elements were detected as shown in table 2 and figure 1.

Table 2. Concentrations of the elements using the ESEM for E2 sample

Element	Concentration (Wt %)	Element	Concentration (Wt %)
Mg	11.14	Ba	58.68
Al	0.38	Cr	0.00
Si	12.99	Mn	0.32
S	11.26	Co	0.18
Ra	0.46	Ni	0.15
Th	0.43	Zn	0.23
Cd	0.26	Hg	1.19
U	0.00	As	0.00
K	0.11	Pb	1.62
Cs	0.00	Se	0.63

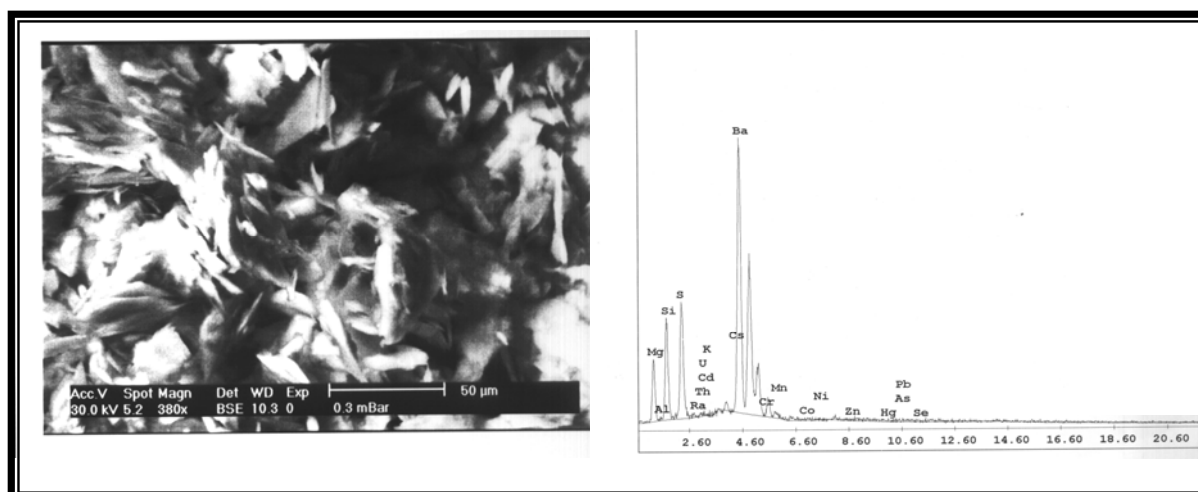


Fig. 1. Results for Environmental Scanning Electron Microscope for E2 sample

4. CONCLUSION

The presence of Ba, Zn, Al, Fe, Si, and Mg elements in the different Egyptian and Hungarian baby talc powder samples were confirmed utilizing Fast Neutron Activation Analysis (FNAA), lifetime, Environmental Scanning Electron Microscope (ESEM) and X-ray fluorescence (XRF) techniques. The concentrations values of elements, of different studied samples (in ppm), have been evaluated employing fast neutron activation method followed by successive gamma-ray measurements. Using ESEM, the concentrations of 20 elements present in sample E2 were also given. The results were discussed in details showing their severe effects on human health when they are deviated from the permissible values. It is highly recommended that the baby powders may be used with caution when it is necessary.

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